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This research was a continuation of the PI's studies of transonic flow about two and three-dimensional lifting wings. The work was carried out in close collaboration with Prof. J.D. Cole, Rensselaer Polytechnic Institute. The investigations were carried out within the framework of small disturbance theroy. Flows about "not-so-slender" wings were investigated, chokes wind tunnel flows were analyzed, and the question of the perturbation of shock free flows was considered. In addition a minisymposium for ICIAM'91 was organized around these topics, and the contributions are to be organized as a SIAM monograph.

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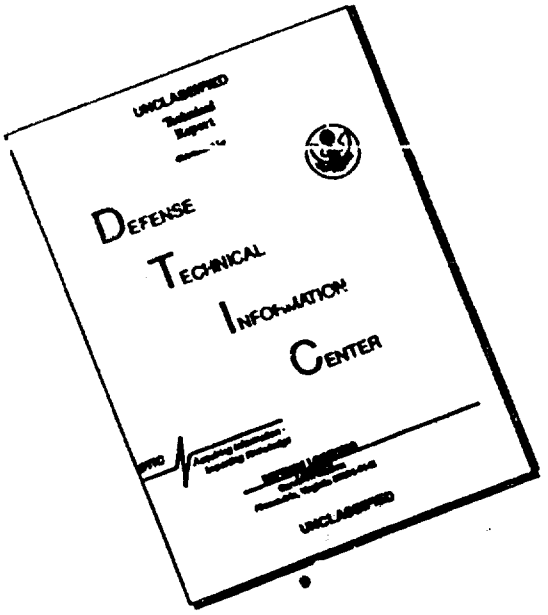

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Mathematical Problems in Transonic Flow

L. Pamela Cook-Ioannidis

AFOSR-91-0113 Final Report

This research was a continuation of the PI's studies of transonic flow about two and three-dimensional lifting wings. The work was carried out in close collaboration with Prof. J.D. Cole, Rensselaer Polytechnic Institute. The investigations were carried out within the framework of small disturbance theory. Flows about "not-so-slender" wings were investigated, choked wind tunnel flows were analyzed, and the question of the perturbation of shock free flows was considered. In addition a minisymposium for ICIAM '91 was organized around these topics, and the contributions are to be organized as a SIAM monograph. [5]

The transonic area rule connects the drag of a wing/body with that of an equivalent body of revolution. The rule was enunciated by Whitcomb based on experiment, and later, based on slender wing analysis, clarified by Oswatitsch and Keune, among others. In our paper [2] using the method of matched asymptotic expansions we provided a systematic derivation of the area rule and we showed how to calculate corrections due to the fact that the wing is not "slender" but rather has an aspect ratio of order one (where the thickness is order δ much less than one). The work in that paper was for a nonlifting wing, we are currently carrying out the analysis for lifting wings.

Choked flow in a wide wind tunnel was analyzed earlier by Cole and Cook. The Mach number in that event is close to one so that analysis similar to that for the Stablization Law, gave the dependence of the choking Mach number on the wind tunnel height. For the two-dimensional case all parameters could be determined in terms of the airfoil shape, but for the axisymmetric case they could not due to the nonexistence of axisymmetric conservation laws at this time. In the work in progress with Schleiniger [4] (to be presented at ICIAM '91) the choking Mach number is computed numerically directly for a double wedge airfoil. Further work will consider other airfoil shapes, axisymmetric wings, and hopefully axisymmetric conservation laws.

Investigations have also been carried out into the perturbation of shock free flows. In this respect some analysis of the Tricomi problems is presently being carried out.

Papers 1991

1. Transonics and asymptotics, in Asymptotic Analysis and the Numerical Solution of Partial Differential Equations (ed. Kaper, Garbey), Lecture notes in pure and applied mathematics, Marcel Dekker, appeared 1991, pp.145-160.
2. Asymptotic theory of the transonic area rule (with J.D.Cole) to appear in Mathematical Approaches in Hydrodynamics, M.P. Tulin anniversary volume, SIAM publica-

tions, 1991.

3. The inlet layer in the flow of viscoelastic fluids (with Schleiniger), to appear in J. of Non-Newtonian Fluid Mechanics.
4. Choked wind tunnel flow: a numerical treatment (with Schleiniger) in preparation. (to be presented at ICIAM 1991, minisymposium on Transonic Aerodynamics).
5. Transonic Aerodynamics, in Frontiers in Applied Mathematics, SIAM Publications, proceedings of the minisymposium at ICIAM '91, in preparation.